Nanotechnology and the Modern University

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NANOTECHNOLOGY IN SOCIETY: ATLAS IN WONDERLAND?

Guest Editors: John V. Stone and Amy K. Wolfe

Departments

world followed a single trajectory of technology adoption, on which the affluent households and offices of the United States were the clear leaders.
- Second, none of the social science research carried out at Intel to date (we have had some such capability since 1995) has concerned itself with what happens at the nano-scale. Most ordinary folk don't directly interact with the microprocessor. Rather, all social science research has been focused on a much more macro-scale, namely, what people do with that processing power, as it hums silently (but increasingly warmly) inside the humble beige desktop PC or sleek laptop.

Yet both of these conditions have been (and continue to be) changing rapidly. MP3 players and countless other devices have proven the "single trajectory" assumption wrong. In different parts of the world, people are accessing each other, the internet, and other dimensions of the digital world through devices other than personal computers with astonishing alacrity. Technology adoption trajectories are multiple and difficult to understand sometimes even in retrospect, let alone to predict. In light of this difficulty, Intel has shifted its perspective considerably: social scientists, in concert with market research, engineers, and designers have been tasked with understanding the complexities of human needs, desires and practices, and how they affect the attitudes towards and uses of technologies. Our purpose is to help our company better address these values and attitudes in the creation not just of microprocessors, but "platforms," constellations of technology that are more closely matched to real human needs and practices—for instance, uses associated with mobile technology use, or, more recently, uses associated with home entertainment and media consumption, or, in the case of my own research group, uses associated with the maintenance or recovery of health.

The second "fact," that the appropriate social scientific inquiry is best focused at the macro-scale, seems likely to change in the very near future as well. Increasing research and development throughout the high-tech industry has begun to focus on the very small not just in terms of transistors, but in terms of fluid manipulation for biological assessment, of implantable (or ingestible) devices, or, perhaps less dramatically, in terms of fabrics into which are woven radio antennae, memory, storage, or simple processors or the kinds of RFID tags referenced above by Dr. David. Technology research in our own corporation challenges what were once easy boundaries between the "person" and the "computer" in both exciting and potentially disturbing ways. By providing scaffolding or supplemental capabilities to those who have suffered cognitive or physical loss, for instance, new technologies might increase personal fulfillment or productivity. By radically reducing the cost of moving information, new health care "professionals" in parts of the world that lack physicians or nurses might be able to provide simple diagnoses to some of the world's three billion people who lack adequate access to health services.

As such capabilities spread throughout a population, even in the most benign scenarios, what might the emergent effects be on families, communities, or nations? Wellman (1999), among others, has suggested that new technologies have made our society into one of "networked individuals," enabling greater personal freedoms, but weakened social network ties. As the cohort of aging baby-boomers takes its place atop the world's changing demographic pyramid, what broader effects will be wrought by the presence of technologies that allow (require?) aging adults to be productive into their seventies, or beyond? What might be the broader consequences of the creation of rapid, in-home blood tests or medical-imaging technologies? How will individuals and families who suddenly realize that they carry risk factors for conditions that threaten their insurance status or employability react on both a personal and societal scale? We can't hope to answer all these questions, but only to raise them, explore them, and continue to advocate for a human-centered perspective in the imagination, development and deployment of these new capabilities.

It Depends on Where You Sit

The three of us are among the growing number of anthropologists whose practice involves or focuses on nanotechnologies. Our pursuits, of course, are influenced by the contexts in which we work—federal laboratory, university, and private industry. These institutions have been, and will continue, to pursue nanotechnology research, development, and deployment, with or without the involvement of anthropologists. We believe that anthropologists can and should play a role in raising questions that may not otherwise be considered, and in using our theories and methods to help address those questions—no matter whether the products of interest are biofuels; RFIDs or other devices that can be implanted or ingested into living beings or incorporated into materials; nano-scale sensors; or nano-processors.

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Amy K. Wolfe *is profiled on page 5.*

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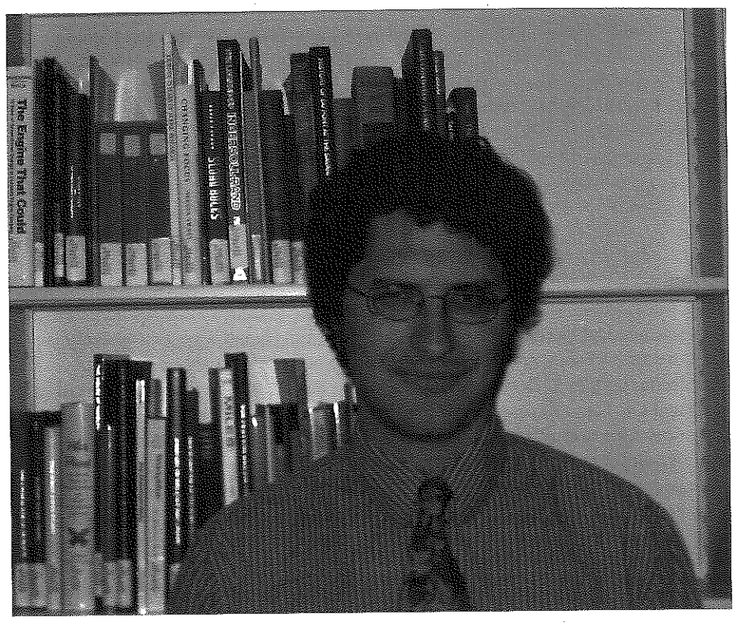
NANOTECHNOLOGY AND THE MODERN UNIVERSITY

By Cyrus C.M. Mody



Cyrus C.M. Mody

The novelty of nanotechnology presents social scientists with an interesting dilemma. On the one hand, the scientists and engineers doing nano research have been at it for such a brief time, and are performing such a diffuse array of activities, that it is very difficult to see *what* social scientists should be studying, much less *how* they should go about it. On the other hand, social scientists who study science and engineering have (at least over the past decade) focused largely on disciplines that are relatively marginal to nano—computing-information technology, genomics-biotech, psychology-cognitive science, economics, and medicine (this gross generalization is based on looking through the program of the annual Society for Social Studies of Science meeting for the past few years). There is very little sociology or anthropology of the core fields of nano (materials science, chemistry, applied and/or condensed matter physics, electrical and mechanical engineering)—though the exceptions are some of the best representatives of social studies of science (e.g. Hugh Gusterson, Laura McNamara, Bart Simon, Harry Collins). Obviously, some lessons from ethnographies or recent histories of biotech, economics, etc. will translate well to the study of nanotechnology; but we should also accept that it will probably take as long for social scientists to develop a methodology *for* nanotechnology as it will take scientists and engineers to develop a practice *of* nanotechnology.

My own path to studying nanotechnology gives a sense of the mutual development of technical and social scientific approaches to the field. I have an undergraduate degree in mechanical and materials engineering, though even in college the questions that interested me concerned engineering's connections to the wider world—how and why does knowledge of materials get made? How do new materials find their way into general use? What is the relationship between the engineering fields' knowledge and practices and those of other communities? To move closer to those questions I began my graduate work in Science and Technology Studies at Cornell by conducting ethnographic research with a group of Cornell materials scientists. Over time, I added an historical dimension to this study and began focusing on instrumentation as a lens for examining the social practice of experimentation—how do communities develop around new instruments? How do those communities relate to the institutions and disciplines of science? How do organizations (e.g. instrument manufacturers or national metrology laboratories) bring widely-dispersed communities into contact with new instruments?

The instruments I chose to study were those used regularly by my informants at Cornell—the atomic force microscope and the scanning tunneling microscope. Today, these instruments are regularly invoked as the breakthrough enablers of nanotechnology. Yet when I began my study in the late '90s, the materials scientists I was working with had barely heard of nanotechnology—the AFM was a tool for "characterizing surfaces" or "studying materials," not for "doing nanotechnology". Yet a few years later, once the National Nanotechnology Initiative became a reality, "doing nanotechnology" was a nearly unavoidable part of being a

materials scientist at Cornell. For my part, it very quickly became impossible to understand the social practice of instrumentation and materials science without examining why people would want to call themselves nanotechnologists—i.e., I quickly needed to learn some techniques for studying nano, and I needed to find other people interested in bringing social science into nano. Fortunately, this "nano-studies" community is now taking shape, particularly through a series of panels at various professional society meetings (the Society for Applied Anthropology, the American Anthropological Association, the Society for Social Studies of Science), dedicated conferences at (among others) the University of South Carolina and the Chemical Heritage Foundation, and the new NSF-funded Centers for Nanotechnology in Society at Arizona State and UC Santa Barbara.

For my own research, I've tried to draw some lessons from my drift (alongside my informants) toward nanotechnology. First, this drifting into nano implies that we need to understand the field's novelty as a social construct. There was plenty of "nano" going on well before that label was applied. We need to understand what values, practices, and social organization were carried through into nano by these fields, and what difference nano makes within and between these "constituent communities." Second, the importance of these constituent communities points to the need to bring historical perspectives to bear on ethnographic data and vice versa. Contemporary approaches alone risk being credulous about nanotechnology's novelty; historical approaches alone risk insularly reifying the communities they study without noticing the nascent connections that link those communities via the nano umbrella. Finally, we need to pay attention to the sites where nanotechnology qua nanotechnology is *presently* and *currently* changing people's lives. The public face of nano—like any emerging technology—is rife with grand pronouncements about how nano *will* change the world, how it *will* be the next industrial revolution. Social science approaches to nano—particularly ethnographies—must put such pronouncements in context by looking at how communities manufacture nano today, rather than setting up outposts in some future world on the assumption that nano *will* be X or Y.

This might seem like a call for an internalist approach to nano—let's study the practices of nanoscientists today, and then follow the products of their work as they diffuse out into the wider world. And, indeed, I think the emergence of nanotechnology (and nano-studies) is a golden opportunity to revitalize laboratory ethnographies—such as the excellent clean room studies being done by Ana Viseu at Cornell and Mikael Johansson at Göteburg. I'd like to spend the rest of this article, though, outlining some ways to broaden this preoccupation with present practice so that it blurs the internal-external distinction while placing nano's grand pronouncements in context.

Let's take, for instance, some of the most well-known corporate manifestations of nanotechnology. Two to three years ago, there were certain times of the week and year (Sunday mornings and afternoons in the spring and summer) when it was difficult to avoid seeing nanotech-themed commercials for Hewlett-Packard and General Electric on network television. Since then, it has become difficult to avoid seeing articles on corporate nano-luminaries such as Phaedon Avouris (of IBM) and Stan Williams (of HP) in certain kinds of publications—*Forbes*, *The Economist*, *Business Week*, *Red Herring*, the *New York Times*, the *Wall Street Journal*, etc. In the past year or so, the high-tech promises about nano in these publications have been matched by the advent of overtly nano-derived consumer goods—golf balls, tennis balls and rackets, invisible sunscreen, stain-resistant chinos.

Obviously, then, nanotechnology *qua* nanotechnology means something for people working at certain companies. IBM, for instance, clearly sees "nanotechnology" as a way to organize its chemists, electrical engineers, materials scientists, and applied physicists to help them offer a compellingly radical alternative to the dominant technological pathways in the microelectronics industry—the linkages, materials, and concepts binding nanotechnology together are exactly what IBM needs in its fight to shift Moore's Law of miniaturization away from traditional silicon. Thus, nanotechnology plays a very specific role in solving these corporations' particular problems; yet it also plays a generic role in the presentation of corporate self. It is no coincidence, I believe, that HP and GE's nano-themed commercials aired during the Sunday political talk shows and golf tournaments (alongside commercials for other blue chip companies like Siemens and ADM), or that nano is such a popular topic in the business press, or that the consumer goods that most loudly trumpet their nano-contents are those such as tennis rackets, golf balls, and chinos that marketers might associate with the same investing class that reads *Business Week* and watches *Meet the Press*, or that nanotechnology became an institutional bandwagon just at the height of the dot.com frenzy in 1999-2000. Nano, in this generic sense, is part of firms' attempt to appeal to investors—a module pulled off the shelf to demonstrate that the company is innovative, dynamic, and *au courant* with the forefront of research.

If social scientists are to understand nano, then, they must confront both these particular and generic aspects. Nano is, on the one hand, a way of tying together pre-existing research traditions in order to yield new solutions to the specific problems of particular institutions—how to make transistors smaller, how to make electronic ink, how to diagnose and cure cancer, etc. On the other hand, it is also *not* novel precisely because it is plugged into a long-standing *discourse* of novelty—another new science for the New Economy. This is not to say that the generic manifestation of nano is simply cynical spin—rather, the construction of narratives of innovation and fore-front research is its own concrete practice, and nano is a new instrument in that practice. Social scientists would do well to study the communities associated with that practice if they want to understand the networks surrounding nanotechnology. I particularly have in mind here the need for a history and/or ethnography of the futurist community—people like Eric Drexler, Marvin Minsky, Stewart Brand, Bill Joy—and the permeability between that community and the world of business forecasting and reporting. Thomas Frank and Fred Turner have given us part of this equation, but a study that extends their ideas to nanotechnology would be wonderful.

As important as corporations are to nano, though, social scientists would (I believe) do well (for the moment) to look more to universities than corporations. Campuses are where nanotechnology is most visibly a *current* and *compelling* practice—again, in both a generic and a particular sense. Corporate researchers have a product line to contribute to, and if nano helps them do that they will associate with it; but universities have a more diffuse objective (Training students? Producing knowledge? Leading culture? Cooperating with nation and industry?) that nano is helping to bring in focus. The flow of investors' money into nano continues to be relatively slight; but the flow of donors' and taxpayers' money in and around universities earmarked specifically for nanotechnology research has been (relatively, of course) quite large. It would be hard to measure this, but my impression is that a large majority of the people who are *changing* their beliefs, practices, networks, etc. specifically because they see themselves as part of the nanotechnology enterprise work for or around universities. This includes a diverse array of people, from academic scientists and administrators, to the architects and construction workers building dozens of new nano centers, to the federal grant officers whose primary job is to fund and coordinate academic research, all of whom *ought* to be at the center of social science approaches to nano, but have been nearly invisible thus far.

Very few—if any—American research universities have allowed talk about nanotechnology to go unnoticed; many have built or are building their own nano centers or institutes or laboratories. A few have gotten NSF funding to call their local nano centers "national" nanofacilities. Nano is trickling slowly into the undergraduate curriculum in chemistry, physics, materials science, electrical engineering, and biology; and at the graduate level, it's providing the platform for new kinds of training and research, and new outlets for partnerships with government and industry. So here we have a set of institutions where nanotechnology means something fairly definite and far-reaching, where nano funding could profoundly reshape the institution, perhaps reinforcing its traditional values or perhaps moving it away from its heritage. There is also a large, semi-public community of people—the university's alumni, donors, and local residents—who are interested in the fate of the institution and can, therefore, be consumers of academic nanotechnology's generic face. Between the institution and this semi-public sphere, then, there is a substantial body of people working in and around universities who construct and disseminate this generic manifestation.

These mediators will be key to the development of nanotechnology and should, therefore, play an important part in social scientific analysis of the field. There is, for the moment, *no* public sphere for nanotechnology that social scientists can poll, prod, or interrogate to find out whether "they" are ready for, skeptical about, or scared of nano. There are, however, a number of these semi-public spheres, porously defined by attachment to some institution, and a large number of mediators who help define the meaning of nano within their particular sphere. Social scientists will, I believe, learn much more about how nanotechnology will or will not be accepted in the general public sphere by working with these mediators than by simply approaching the public *en masse*.

To get a sense of what I mean here, I decided to take a look at one of the quintessential products of these academic semi-public spheres—the university alumni magazine—in preparation for a talk at the Society for Social Studies of Science annual meeting. I'd been interested in how universities use nanotechnology to navigate internal and external institutional pressures for a while; but the immediate trigger for looking at alumni magazines was seeing two feature articles (one from my own

Photo by Cyrus C.M. Mody

Magazines Addressing Nanotechnology

alma mater and one from a friend's) in the space of a week. Cursory digging then turned up more than a dozen other pieces from the past few years. This was a very brief study, and the observations below are merely a first glance at some obvious patterns. An in-depth of ethnography of how university PR and administrative offices deal with science would be a wonderful thing (as Daniel Lee Kleinman and Jason Owen-Smith have demonstrated); but this article is not that. Instead, I compiled a small archive of alumni magazines related to nanotechnology, tried to read a few articles from those magazines on other new sciences (especially biotech), and then conducted half-hour phone interviews with a half-dozen authors—some freelancers, some university employees.

Interestingly, this methodology is quite similar to that used by my informants themselves. Each of these authors drew on interviews with leading nano scientists and engineers (and a few social scientists or philosophers) on campus, plus the usual tour of labs and clean rooms (which I too have done). I think this paralleling of actors' and analysts' methodologies—what George Marcus calls "paraethnography"—is a good place for social scientists' to start in looking at nano for two reasons. First, the kinds of mediators I talked with for this study are playing a similar role to that of the social scientist—crafting both a particular story and a generic representation (or, for social scientists, a generic theory). These people will have insights about method and content that are worth drawing on. At the same time, this similarity of purpose should be cautionary as well. These authors are constructing representations of nanotechnology to buttress particular ideologies and institutions. Critique of their constructions should help us, as social scientists, to be skeptical about our own aims and claims.

For instance, like *Forbes* or *The Economist*, these magazines are, in some sense, pitched to an investing class—some are filled with ads for Italian sports cars, high-end hedge funds, and classifieds for chateaux in Provence—and, therefore, they similarly construct nanotechnology as an investor-class science. But unlike these general, business-oriented publications, alumni magazines reach out to a rather well-defined (though certainly not monolithic) audience, partly to encourage investment (in the university, rather than any business) but also to generate good will and strengthen community. Thus, only when the institution at the heart of that community—the university—undergoes significant, nano-related changes, do alumni magazines take notice. Thus, in the past couple years, where there are nanocenters being built, articles have appeared—in (among others), *Stanford Magazine,* the *Pennsylvania Gazette*, *On Wisconsin*, and *Harvard Magazine*, MIT's *Technology Review*, and Caltech's *Engineering and Science*.

These articles mediate the generic and particular versions of nanotechnology in very interesting ways. Almost all of them narrate a roll call of the scientists and engineers (and sometimes social scientists or philosophers) doing nanotechnology at the university—often accompanied by images of the most photogenic nano researchers and nanomaterials. Notably, the technical content of what these researchers are doing is simultaneously crucial and peripheral to these articles. The authors go into sometimes excruciating detail about dozens and dozens of rather arcane experiments; and yet, that detail is important less as content to be transmitted to the public than as a means for amplifying and reaffirming (or perhaps reshaping) a core message about the institutions to which science is coupled. Nanotech is, in most of these articles, a fairly unmemorable text that carries with it *the* crucial subtext—our campus is X and Y, everything you remember it being, and yet so much more as well, and here are some stories about nanotechnology that reinforce that message.

What you see, then, is nanotech repackaged to exemplify core positive values—even stereotypes—of the university, while minimizing its less attractive features and demonstrating its worthiness for the new century. Each of these articles—sometimes subtly, sometime not—plays to an entrenched image of the particular university. Sometimes this is deliberate—some authors are recruited from within the campus PR machine and know exactly what to emphasize. So, for instance, the Harvard article is long, rather labored, rather insistently educative and edifying, plodding through a half dozen experiments in glorious, nerdy detail—and, as the author (who is also the magazine's managing editor) told me, the overt mission of the magazine is not to be a mouthpiece of the university (indeed, it's an independent entity), but to be a vehicle of continuing education (and yet, one needs only see the advertising to understand that all this educative text carries a subtext of endowment-building). So in the frame of the article, nanotech exists at Harvard not to make money or promote national security or any of the things it is associated with in other universities' semi-public spheres; rather, for Harvard alumni, nano is there simply to ensure that both current and former students continue to get the insistently edifying and rather arcane educations to which they've become accustomed.

Contrast this with the Berkeley magazine's view of nano, where a different but not unexpected set of campus images is served: first, profiles of the Third World childhoods of, and continuing international humanitarian work done by, Berkeley nanotechnologists; and, second, a *mea culpa* that past research at Berkeley—particularly in biotechnology—has cuddled too close to the military or corporations like Novartis, but that nanotechnology (while bringing sensible gains to economic growth and national security) will be constrained by new safeguards that ensure Cal's progressive tradition is not suborned. The contrast here is quite stark—the Harvard article contains no mention of commerce or the military, indeed almost no mention of societal benefits of the research; nor does it contain any mention of the personal backgrounds of its scientists.

So these articles take the local details of nano and recraft them in ways that are both generic (any science would do for the purpose) and specific to that university (nano must reinforce that which makes *this* university different and special). Even when the authors are freelancers with no particular connection to the institution, the same message gets out, largely through the work of editors and the voices of interviewees. So, even though the author of the *Penn Gazette* article isn't associated with Penn and isn't particularly familiar with the university, the message he got from editors and interviewees relayed a Penn-centric view of the world that should be familiar to those who know the university—we're doing "pure" or "fundamental" science, we're not interested in commerce, we're making basic discoveries that will enable other people to cash in rather than developing new technologies ourselves. The *Stanford Magazine* piece, also written by an outsider, flips this around for a typically Stanford message—nano research at Stanford "isn't just an academic exercise. It paves the way": for beating Moore's law, for new modes of manufacturing, for new partnerships with commerce, especially in Silicon Valley—all the things research at Stanford has a self-conscious tradition of doing.

Of course, everywhere there's a norm to reinforce, there's a counternorm to invoke. Everywhere these schools are giving the old college try, they're also packaging nano as a way to shake off musty old values—we hear, for instance, that Northwestern is out there patenting research and encouraging professorial start-ups because "Chicago and the Midwest missed the information technology boom and largely missed biotechnology, but we are not going to miss nanotechnology." Or a *Tech Review* piece on Eric Drexler—"Moses of the Nanoworld"—takes the line that, yes, MIT trained Drexler, but the Institute's association with far-out futurism is so 1970s; nowadays, MIT is much more interested in what real nanotechnologists like Whitesides and Smalley have to say than dreamers like Drexler. From ethnographic work I've done at scientific trade shows, I've seen this same technique used quite widely in universities' and regions' representations to technical communities. That is, positive connotations are continually and unironically embraced, while negative stereotypes are commented on as yesterday's news. For instance, the Massachusetts pavilion at the 2005 Biotechnology Industry Organization show presented a number of variations on this theme: Massachusetts has a four century tradition of commitment to higher education (*ergo* heritage dictates that our workforce is well-suited to laboratory work); but anything you may have heard about the power of labor unions in the Bay State is no longer true (i.e., our workers have updated themselves by casting off bad traditions of labor activism).

And yet, for all that these magazines evoke particular associations between nanotechnology and the specific attributes of their university, there's a remarkable consistency among these articles. We see the same tropes over and over and over again. Even the titles—especially the titles—are tremendously repetitive: "Small Science;" "Nanotechnology: Big Ideas in Small Packages;" "Small Is Big;" "Smallville;" "Small Technology, Big Promise;" "Thinking Small;" "Small Wonders." Yet it's not just lack of imagination at work here; the same themes continually get evoked precisely because nanotechnology helps alleviate some of the institutional pressures that face all universities (certainly all American research universities—it would be an interesting extension of this study to look at smaller schools, community colleges, or universities in other regions). Campus nano is almost always represented as: (1) interdisciplinary—this gets hammered home continually as an issue of "we're all playing in each other's sandbox for the good of the world"—it's not too much of a stretch, I'd say, to see in this a reflex of American universities' obsession with diversity. (2) Campus nano is commercial—in a climate where universities are scrambling for funding and adjusting to a society that seems more oriented to the market than ever, magazines present nano as yet another tool for the institution to make itself leaner and more corporate. And (3) campus nano is solving *your* problems as a citizen and a member of the investor class—in a world where many deans and chancellors feel themselves on the front lines of the culture wars, nano is presented as the university's answer to its nation's call.

This is, I'd say, the real story about nanotechnology—that wherever we find nano, we see it balanced between the local and the global. These alumni magazine articles balance two sets of family resemblances—on the one hand, nano looks like everything else that a particular university does, a comforting reminder to alumni about what makes their *alma mater* special and how it's still what it was, but better; and on the other hand, nano here looks a little like nano everywhere—this university answers to many of the same pressures as all the others. If we want to understand nanotechnology, we won't get much from the big picture, the pronouncements of Mike Roco or Rick Smalley or Eric Drexler—we have to look at this middle level instead, where a sphere is being created for nano that is neither strictly private nor wholly public. We have to understand why particular institutions respond to the call of nano, and how they repackage it to exemplify what those institutions purport to be about—and yet, we have to recognize the encompassing environment those institutions face that shapes nanotechnology at all points.

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